A. K. Pandey* & Amita Kumari*:　**Development and structure of seeds and fruits in Compositae, *Zinnia* species**

A. K. パンディ*・A. クマリ*:　キク科ヒャクニチソウ属の
種子と果皮の形成

Tribe Heliantheae of family Compositae includes 150 genera and 2500 species (Stuessy 1977). In spite of being one of the largest tribes, developmental anatomy of cypsela in the members of this tribe has been studied only in some taxa (Kapil & Sethi 1962, Chopra 1968, Misra 1972, Sundara Rajan 1972, 1974, Chopra & Singh 1976, Pandey 1976, Maheswari Devi & Ranjalkar 1979, Pullaiah 1982, Pandey & Singh 1982, Stuessy & Liu 1983, Maheswari Devi & Padma 1985). *Zinnia*, a member of tribe Heliantheae comprises 20 species (Willis 1973). A perusal of literature reveals that development and structure of seeds and fruits in this genus has not been studied. The present communication, therefore, deals with these aspects in *Zinnia elegans* Jacq. and *Z. linearis* Benth., both being ornamental annuals.

Materials and methods Materials collected locally were fixed in formalin-acetic-alcohol and stored in 70% ethanol. Usual methods of dehydration and embedding were followed (Sass 1958). Serial microtome sections (8–15 μm thickness) were cut and stained in safranin-fast green combination.

Observations Ovary and ovule. The syncarpous and unilocular ovary contains a single anatropous, unitegmic and tenuinucellate ovule (Figs. 1A, 2A). Vascular supply of the ovule enters through funicle, overarches the chalaza and ends on the antiraphe side of the integument (Fig. 2A). Similar pattern of vascular supply has been reported by Venkateswarlu (1941) in *Zinnia elegans*.

Integument. The integument at the organised female gametophyte stage is 9 to 12 cell-layers thick (Figs. 1B, 2B). Cells of its inner epidermis elongate radially, accumulate dense cytoplasm and differentiate as a distinct endothelium. Structure and behaviour of endothelium in these species have already been reported by Pandey (1980).

Endosperm and embryo. At globular embryo stage, the endosperm completely fills the embryo sac (Fig. 2E). Simultaneously, the cells of the outermost

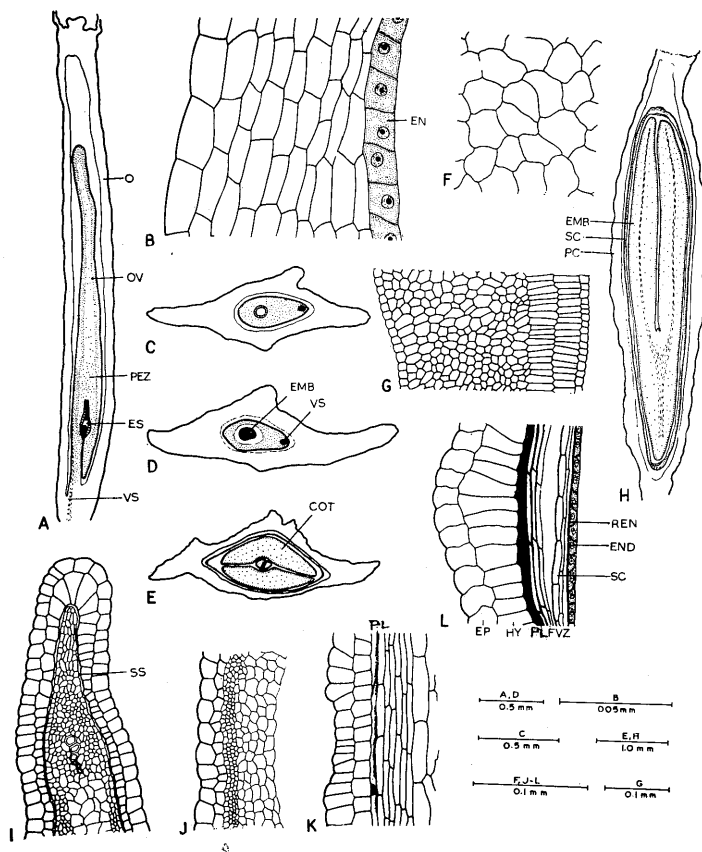* Post-Graduate Department of Botany, Bhagalpur University, Bhagalpur-812007, Bihar, India.

Fig. 1. *Zinnia elegans*. A. Longitudinal section of ovary and ovule at organised female gametophyte stage. B. Longitudinal section of part of integument at the same stage. C, D. Transverse sections of ovary and ovule at organised female gametophyte and globular embryo stages respectively. E. Transverse section of mature cypsela. F. Epidermal cells of mature seed coat in surface view. G. Longitudinal section of part of cotyledon showing palisade layers. H. Longitudinal section of mature cypsela. I, J. Transverse sections of part of ovary at organised female gametophyte stage. K. Longitudinal section of part of ovary after fertilization. L. Longitudinal section of part of mature cypsela. (COT: cotyledons, EMB: embryo, EN: endothelium, END: endosperm, EP: epidermis, ES: embryo sac, FVZ: fibrovascular zone, HY: hypodermis, O: ovary, OV: ovule, PEZ: periendothelial zone, PC: pericarp, PL: phytomelan layer, REN: remnants of endothelium, SC: seed coast, SS: schizogenous space, VS: vascular supply.)
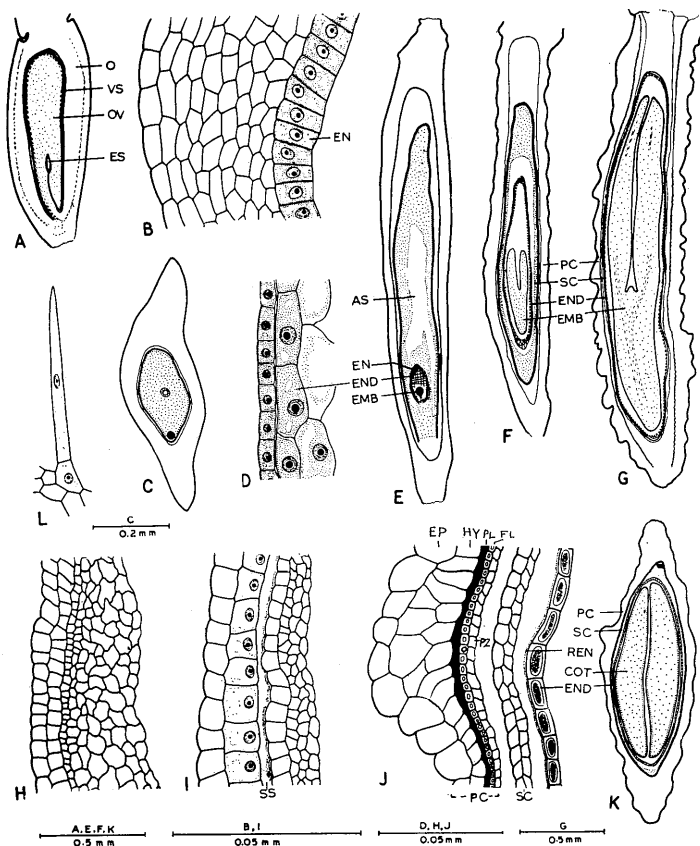
Fig. 2. *Zinnia linearis.* A. Longitudinal section of ovary and ovule at organised female gametophyte stage. B. Longitudinal section of part of integument at the same stage. C. Transverse section of ovary and ovule at organised female gametophyte stage. D. Longitudinal section of part of seed at globular embryo stage. Note prominence of endosperm cells. E, F. Longitudinal sections of ovary and ovule at globular embryo and well-differentiated cotyledonary stages respectively. G. Longitudinal section of mature cypsela. H, I. Longitudinal sections of part of ovary before and after fertilization respectively. J. Longitudinal section of part of mature cypsela. K. Transverse section of mature cypsela. L. Epidermal hair. (AS: air space, COT: cotyledons, EMB: embryo, EN: endothelium, END: endosperm, EP: epidermis, ES: embryo sac, FL: fibrous layer, HY: hypodermis, O: ovary, OV: ovule, PC: pericarp, PL: phytomelan layer, PZ: parenchymatous zone, REN: remnants of endothelium, SC: seed coat, SS: schizogenous space, VS: vascular supply.)

layer of the endosperm accumulate dense cytoplasm and differentiate as a prominent layer (Fig. 2D). As the seed grows, liquidation of the endosperm follows and in a fully mature seed, only its outermost layer persists (Figs. 1L, 2J, 3B). In *Z. linearis* the endosperm cells are more thickened as compared to *Z. elegans* (Figs. 1L, 2J).

The mature embryo occupies the whole length of the seed (Figs. 1H, 2G). The hypocotyl-root-axis is shorter than the cotyledons. In a longitudinal section the cotyledons show two layers of palisade zone on the ventral side below the epidermis (Fig. 1G). Average length of embryo, hypocotyl-root-axis and cotyledons is given in Tab. 1.

Seed coat. Soon after fertilization, a few cell-layers around the endothelium enlarge considerably, become highly vacuolated and differentiate into a periendothelial zone (Figs. 1A, 3A). The cells of the integument lying in the chalazal region show stretching in the plane along the long axis of the ovule. The endothelium remains uniseriate throughout the length of the embryo sac. By the time embryo reaches globular stage, the cells of the periendothelial zone get disorganised and an air space is formed around the endothelium (Figs. 1D, 2E). The air space extends deep into the chalazal region also.

In a fully mature seed, the seed coat is represented, in general, by two layers of cells (Figs. 1L, 2J). The number of layers in the seed coat is more on the micropylar and chalazal sides. The endothelium is seen as a thin cuticular layer closely adpressed to the endosperm. In *Z. elegans*, however, endothelium remains cellular on micropylar side (Fig. 3B). The epidermal cells of seed coat in surface view show irregular outline (Fig. 1F). Thickening of any type is not seen in these cells.

Ovary wall and pericarp. Outline of the ovary is nearly elliptical in a cross-section at the organised female gametophyte stage (Figs. 1C, 2C). In *Z. elegans* a small hump is present on one side (Figs. 1C, 3A) and this forms a distinct ridge in the mature fruit (Figs. 1E, 3C). The ovary wall at this stage is distinguishable into two zones, outer and inner. The outer comprises epidermis and hypodermis and the inner includes rest of ovary wall (Figs. 1J, 2H). The inner zone is again distinguishable into two regions. The outer region is composed of compactly arranged smaller cells which constitutes the profibrous zone and the inner region is made up of large parenchymatous cells (Figs. 1I, J). In *Z. elegans*, the cells of the profibrous zone begin to separate
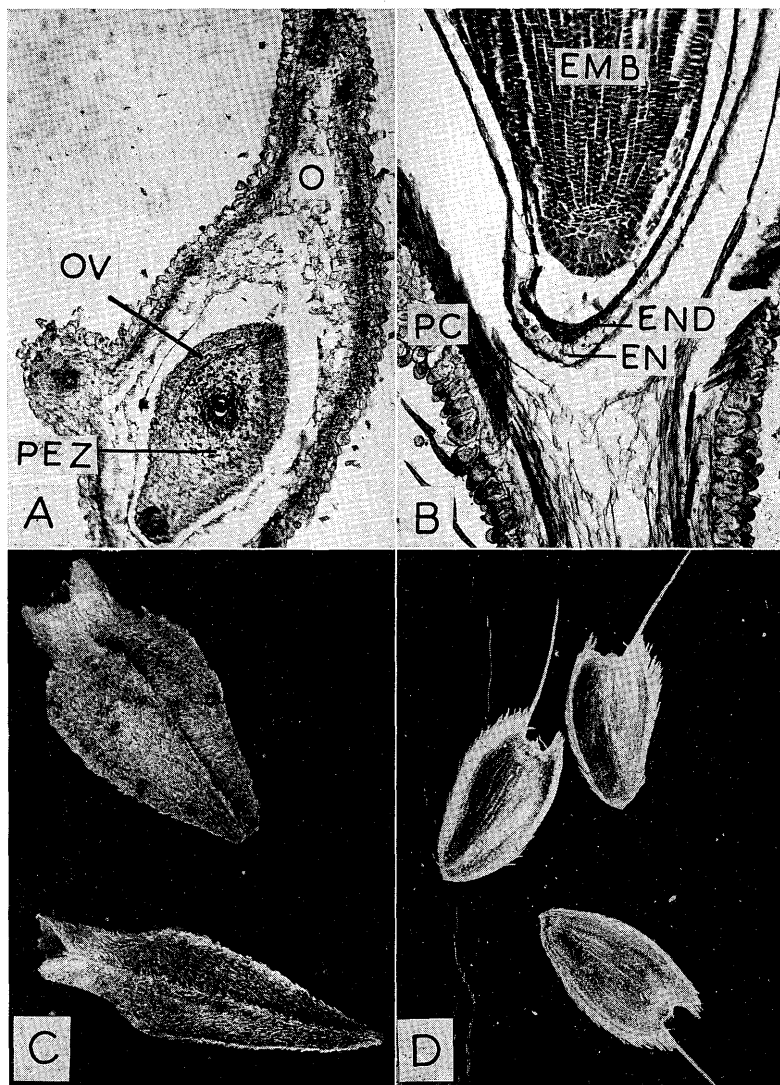
Fig. 3. A–C. *Zinnia elegans*. A. Transverse section of ovary and ovule at organised female gametophyte stage, ×96; B. Longitudinal section of part of mature cypsela, ×102; C. Mature cypsela, ×10. D. *Zinnia linearis*. Mature cypsela, ×15. (EMB: embryo, EN: endothelium, END: endosperm, O: ovary, OV: ovule, PC: pericarp, PEZ: periendothelial zone.)

Tab. 1. Size of cypsela, length of embryo, hypocotyl-root-axis
and cotyledons (measurements in mm).

Species	Cypsela (l. × b.)	Embryo	Hypocotyl-root-axis	Cotyledons
Zinnia elegans	7–10 × 3–5	4. 60	1. 35	3. 25
Zinnia linearis	2–2. 5 × 1–1. 5	2. 00	0. 80	1. 20

from the hypodermal zone and this phenomenon starts from the wing region of the ovary (Fig. 1I). Separation of the two zones is, however, not seen in *Z. linearis* at this stage. Simple unbranched two-celled hairs are seen over the young ovary (Fig. 2L).

Soon after fertilization, the inner zone of the ovary wall begins to separate from the outer zone in *Z. linearis* while the separation of the two zones which started before fertilization in *Z. elegans* is, more or less, complete by this time. The hypodermal cells in both the species become glandular and start secreting phytomelan in the schizogenous space (Figs. 1K, 2I). In *Z. linearis*, when the cotyledons are well-differentiated, the cells of hypodermis divide anti- and periclinally at some places resulting in elevations and depressions (Fig. 2F), but in *Z. elegans* the hypodermal cells do not divide.

In a fully mature fruit of *Z. elegans* the epidermis and hypodermis remain one layer thick and the cells of the latter are radially elongated but the elongation is not uniform throughout. This results in wavy outline of the fruit (Fig. 1H). In *Z. linearis* the epidermis is single-layered but the number of hypodermal cells greatly varies at intervals (Fig. 2J). This results in the wavy margin of the pericarp (Fig. 2G, K).

After filling the schizogenous space, phytomelan starts pressing the hypodermal cells thus giving an undulating appearance (Figs. 1L, 2J). The cells of profibrous zone in both the species become thick-walled and stains red with safranin. The number of sclerosed cells is more in the wing region. The cells of the innermost parenchymatous zone remain thin-walled (Fig. 2J).

Fruit. Mature cypsils of *Z. linearis* are black in colour. The base of the fruit is narrow and stylar side is broad (Fig. 3D). The body of the fruit shows white hair. There is one prominent pappus seen projecting from the stylar base. White silky pappus are present at the base as a tuft. Both ovaries

of ray and disc are fertile and the fruits are similar in all respects except ray fruits being a little larger than the disc ones.

Mature fruits of *Z. elegans* are light brown to dark brown in colour. Their colour depends upon the quantity of the phytomelan present. The pappus is persistent and is in the form of a tube. Pappus tube is longer in ray cypsils and shorter in discs. Under a stereoscopic binocular the fruit shows small tubercles throughout the length. Small cream coloured hair are seen all over the fruit body. The fruit shows a distinct ridge on the ventral side (Fig. 3C) whereas dorsal side is uniform. No ridge is present in *Z. linearis*. Size of the fruits is given in Tab. 1.

Discussion Uniform pattern of pericarp development and differentiation has been observed in both the species of *Zinnia* with minor variations. The outer epidermis of the pericarp is single-layered followed by a prominent hypodermis. The pericarp of both the species shows undulations. In *Z. elegans* the undulations are caused by the differential elongation of hypodermal cells but in *Z. linearis* undulations are formed by the division of hypodermal cells. The hypodermal cells after fertilization become glandular and start exuding phytomelan in the schizogenous space created due to the separation of the two main zones of the ovary wall. Formation of schizogenous space and phytomelan layer is characteristic for tribe Heliantheae (Kapil & Sethi 1962, Chopra 1968, Misra 1972, Sundara Rajan 1972, 1974, Chopra & Singh 1976, Pandey 1976, Maheswari Devi & Ranjalkar 1979, Pullaiah 1982, Pandey & Singh 1982, Stuessy & Liu 1983, Maheswari Devi & Padma 1985). The main mechanical zone of the pericarp is constituted by the fibrous tissue which forms a continuous zone in the pericarp, a feature reported in majority of Heliantheae (Pandey & Singh 1982, Maheswari Devi & Padma 1985).

The mature seed coat is composed of two layers of parenchymatous cells and the cells do not show any type of thickening. Characteristic fibrous thickenings in the epidermal cells of the seed coat have been reported in some Heliantheae viz., *Galinsoga parviflora*, *Parthenium hysterophorus*, *Wedelia calendulacea* (Pandey 1977), *Verbesina encelioides* (Misra 1972), *Eclipta erecta* (Pandey 1976, Maheswari Devi & Ranjalkar 1979), *Wedelia urticaefolia* (Maheswari Devi & Ranjalkar 1979).

In mature seeds, endosperm remains single-layered as also observed in other Heliantheae (Maheswari Devi & Padma 1985).

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　ヒャクニチソウ属 2 種の種子と果皮の構造を調べた。胚形成の初期に胚嚢は胚乳で満たされるが，胚の成長と共に内側から分解する。種子が成熟した時期には 1 細胞層からなる胚乳だけが残る。珠皮は 9-12 細胞層からなる。その最内層は endothelium となる。珠皮の内層は分解して空隙を作り，胚乳や胚の発達と共に圧迫され，成熟期には最外層と薄くなった endothelium の 2 層によって果皮が作られる。子房壁は外側の 2 細胞層，原繊維細胞層，柔細胞層の 3 層に区別される。外側の 2 細胞層と原繊維細胞層との間に空隙ができ，そこに phytomelan が分泌されて空隙を埋める。成熟した果皮は外側に大きな細胞からなる 2 細胞層，繊維組織層，柔細胞層の名残の 1 細胞層からなる。

□Callow, J. A. & H. W. Woolhouse (ed.) : **Advances in botanical research, vol. 11** 205 pp. 1985. Academic Press, Orland, Florida. $55. 植物学のあらゆる分野の研究について，主として review 論文を取扱い，その分野での研究がどこまで進んでいるかを取りまとめるシリーズで，約 1 年に 1 冊の割りで出版されている。第11巻には 4 篇の論文が掲載されていて，細胞内の諸器官の研究にレーザー光線を利用する方法に関するもの，海藻類における無機炭素の吸収と移動について論じたもの，種子における炭水化物の問題を取扱ったものの他，特異な種子植物である *Welwitschia* に関して，主として水分経済の面から考察した論文とがある。この *Welwitschia* は，貯水能力が乏しく，常緑の大きな葉をもち，他の生理的な性質からも，砂漠地に適応したものとはとても考えられないとしている。　　　　　　　　　　　　　　　　　　（井上　浩）

□竹田孝雄: **広島県のシダ植物** 560 pp. 1987.　博新館，広島市西区南観音 7-7-1.￥10,000. 著者は広島県に住み長年郷土のシダを研究してきたが，特に最近17年間の調査結果をまとめたのが本書である。広島県で確認された種と変種の計 240 種類について，図と分布図を見開きに並べた図鑑である。図は全部おし葉標本の写真でＢ 5 判のページ一ぱいをとっていて，細かい所までよく出ている。分布図は全県に 2 万 5 千分の一の地形図の網を被せてできた 100 個の升目のある地図に，〇印で存否を示してある。図と地図の余白には簡単な記事（区別点，生態，分布など）が記載されている。24品種と36雑種については分布図か産地を挙げている。なお文献だけで確認のとれないもの，絶滅したらしいものなど約30種類を「まぼろしのシダ植物」として紹介している。種や変種の大きさなどはよくバランスがとれていて，研究者にも初心者にもそして県外の人にも役立つ書物といえる。　　　　　　　　　　　　　　　　　　　　（伊藤　洋）